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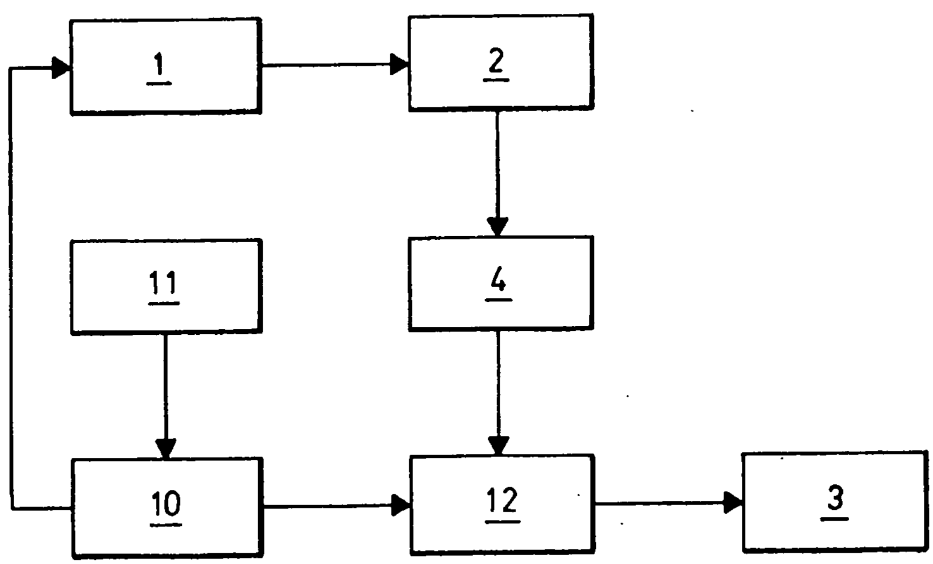
(54) Title: GRID ZONES SUCCESSIVE IRRADIATION



(57) Abstract

A primary zone is delimited on a body to be irradiated and radiation is subsequently directed to irradiate the body at different locations within the primary zone in a predetermined sequence. The primary zone is typically geometrical in shape and capable of tesselation. The primary zone is typically imaged on the surface of the body by a scanning beam. The predetermined sequence of irradiation is controlled by a microcontroller having stored sequence data determining the scanning of a "working" radiation beam to impinge upon specific locations in the required sequence.

GRID ZONES SUCCESSIVE IRRADIATION

The present invention relates to irradiation of a body, and in particular to irradiation of a body in a controlled manner.

It is often desirable to irradiate bodies by means of, for example a beam of laser radiation. It is often desired to ensure that the radiation beam scans a predetermined area of the surface, for example, when it is desired to change the properties of the surface of a body or of a sub-surface region by means of the radiation beam.

When the material being irradiated is thermally sensitive or light-sensitive it is desirable to avoid over-exposure of any individual spots. For example, when subjecting skin or other body tissue to laser radiation, there is frequently a build-up of thermal energy and pain in the area directly exposed to irradiation and also in the immediate vicinity of that area. Increased laser exposure can cause thermal "injury" and tissue trauma as well as pain. For such procedures the thermal dissipation time, which is the time taken for 50% of the thermal energy to dissipate from an irradiated area, is generally less than 20mS, such as about 3mS.

The removal of wrinkles and the resurfacing of skin is currently achieved by the application of CO_2 laser radiation to skin tissue. The method removes the skin tissue layer by layer. The first layer removed achieves what is known as resurfacing and creates a new skin surface without blemishes which may have existed previously. As the second and later layers are removed, controlled thermal "injury" and tissue trauma is caused to the collagen, which then forms cross links. This induces shrinkage in the dermis of the skin and hence wrinkles are reduced in amplitude or are removed altogether.

The treatment produces a second degree burn and the skin barrier layer is removed and therefore, there is a danger of infection. This method is traumatic, painful, and can require an extended healing time.

Other procedures in which laser radiation is directed at mammalian tissue include treatment of birthmarks (such as vascular lesions and pigmented lesions), and depilation. Again, there can be a problem and tissue damage if any individual spots are over-exposed to laser radiation.

In other non-biological material treatment or marking procedures it is often desirable to apply radiation in a predetermined and controlled manner to produce desired results. For example in the laser marking of glass it is desirable to closely control the heat build up in the material to ensure attain the correct reflow conditions and temperature.

An improved irradiation technique has now been devised.

According to a first aspect of the present invention, there is provided a method of irradiating a body, which method comprises;

i) delimiting a primary zone on the surface of the body to be irradiated;

ii) directing radiation to irradiate the body at a plurality of predetermined locations within the primary zone in a predetermined sequence.

According to a second aspect the invention provides apparatus for irradiating a body, the apparatus comprising:

i) delimitation means for delimiting a primary zone on the surface of the body toward which radiation is to be directed; and,

ii) control means for controlling delivery of radiation toward the primary zone, the control means directing radiation to irradiate the body at a plurality of predetermined locations within the primary zone in a predetermined sequence.

In a preferred embodiment of the present invention, the primary zone may be a superficial area of mammalian skin tissue.

The delimitation means preferably delimits the primary zone as a zone of predetermined configuration, preferably of a space filling shape which is arranged to tesselate. This provides that succesive primary zones may be mapped in a tessalating arrangement over arelitively large surface ensuring that all regions to be treated are at one time located within a primary zone. The provision of the delimiting means ensures that before radiation is delivered , the position of the ptimary zone can be checked to ensure that there is no overlap with a previously irradiated primary zone (which would otherwise result in radiation over exposure of overlapping regions. The shape of the primary zone delimited is preferably a hexagon.

The delimitation means preferably comprises means for non-physically mapping the primary zone on the surface of the body, advantagously by imaging the shape of the primary zone on the surface of the body. In a preferred embodiment, the delimitation means comprises means for projecting an image onto the surface for example by scanning a beam rappidly to trace the outline of the shape of the primary zone. Desirably, the delimitation means is provided with means for manipulating the size and or configuration of the primary zone delimited.

Irradiation of the entire primary zone is preferably by a beam of radiation (advantageously laser radiation) preferably delivered as a sequence of pulses. In one embodiment, the sequence may be such that no spot is irradiated for a predetermined time (dependent upon the thermal relaxation time of the material comprising the body) after irradiation of a neighbouring spot. This may be achieved by ensuring that the sequence of irradiating the predetermined locations within the primary zone is such that spatially adjacent locations do not correspond to sequentially adjacent locations.

Such a regime is particularly advantageous for irradiating skin tissue. The thermal dissipation time for irradiated skin tissue is typically 2 to 3mS, so that a subsequent pulse can be fired impinging a spot adjacent to a preceding irradiated spot after 2 to 3mS. Therefore thermal injury and pain accumulation in the skin tissue can be prevented by irradiating neighbouring spots after the thermal dissipation time.

Preferably, when a pulse is fired at a location within the primary zone, further non adjacent locations are irradiated elsewhere within the respective primary zone during the thermal dissipation time of 2 to 3mS; then once said thermal dissipation time has passed, the radiation beam is controlled such that a location is irradiated adjacent the first irradiated location. This provides a rapid way of treating the entire primary zone.

In an alternative embodiment, where controlled heat build up and accurate beam manipulation is required (for example for thermal material marking or etching), the sequence of irradiating the predetermined locations within the primary zone may be controlled such that spatially adjacent locations correspond to sequentially adjacent locations.

The time between switching the beam between sequentially consecutive locations and the "beam on" time is preferably closely controlled.

The control means (typically comprising a microcontroller arrangement) preferably includes data store means carrying stored data relating to the predetermined locations to be irradiated in the primary zone. The data store means preferably includes sequence data dictating the predetermined sequence for irradiation of the predetermined locations within the primary zone, and desirably a flag arrangement, wherein respective flags are set from a first condition to a second condition in order to confirm that a respective location of the primary zone has been irradiated.

Desirably, the predetermined locations are assigned to respective elements in the data store representative of a grid or array. Data defining the relevant shape and size of the primary zone delimited is preferably carried in the data store, and the relevant primary zone configuration ia arranged to be mapped onto the grid or array.

Each grid or array element is desirably alloted a predetermined respective position in the heirarchy of the predetermined sequence of irradiation. The grid or array preferably comprises a plurality of sub-zones, respective sub-zones comprising a grouping of respective grid elements or array elements and being assigned a respective heirarchical position in the predetermined sequence of irradiation, and wherein irradiation of a location assigned to a respective grid or array element in a first sub-zone is followed by irradiation of a location assigned to a respective grid or array element in a second sub-zone prior to irradiation of a further location assigned to a respective grid or array element in the first sub-zone.

When substantially all of a first primary zone of said area has been treated with successive pulses of laser light, further zones of said area can be irradiated in an identical manner. Preferably, a plurality of further zones of said area is irradiated such that substantially all of said area is irradiated.

The control arrangement preferably further includes a radiation director arrangement, the radiation director arrangement being reorientatable to direct the radiation in sequence to the plurality of locations within the primary zone. The radiation director arrangement preferably comprises a pivotable deflector or reflector arrangement, advantagously driven by a motor controlled by the control arrangement. Typically, the arrangement comprises X and Y co-ordinate reflecting mirrors preferably of galvanometer type controlled by an analogue signal derived from the controller arrangement (preferably via a digital to analogue converter).

An additional aspect of the invention relates to the controlled deployment of a plurality of radiation beams. The use of such a deflector arrangement enables a plurality of radiation beams to be utilised, each directed to irradiate the body at a plurality of predetermined locations within the primary zone in a respective predetermined sequence. The plurality of radiation beams may be sequenced to be directed at spaced temporal intervals to the same predetermined locations within the primary zone in a respective predetermined sequence.

The use of such an arrangement enables beams impinging along a plurality of angularly spaced axes to be directed to impinge sucessively at the same location. This is believed to be novel and inventive in its own right.

It is preferred that the predetermined space-filling geometrical shape comprises a hexagon, which is irradiated by a sequence of pulses such that substantially all the surface area within the hexagon is irradiated. Alternatively, a sequence of pulses can be irradiated along a desired path within the hexagon, such as, along a wrinkle line.

In one embodiment of the invention, the primary zone can be stretched horizontally and/or vertically to accomodate the treatment area, so that the treated skin tissue can be stretched in a desired direction to enhance wrinkle removal.

Applying laser radiation to skin tissue in an "intelligent" manner according to the invention can induce a controlled shrinkage of the collagen in the dermis, maximizing the cosmetic result. The collagen would then be denatured and form cross links. The resulting tightening would stretch the skin reducing or removing the wrinkles. The thermal threshold for this effect is a temperature of about 70^0C.

The irradiation may be from a laser source of coherent visible or infra-red radiation. Such a laser source may include a ruby laser. The laser source is preferably pulsed, with a pulse duration of 200μS to 1mS, and with an energy density of 10 to 25J/cm^2. The spot size produced is typically in the range 3 to 10mm (such as about 5mm).

If the laser source is operated at a wavelength of 585nm, the present invention may be used in the treatment of vascular lesions; if the wavelength is about 694nm, the present invention can be used for depilation (removal of unwanted hair).

The present invention can be used with short pulse (Q-switched) lasers for the treatment of pigmented lesions and tattoo removal.

The invention will now be described in specific embodiments by way of example only with reference to accompanying drawings, in which:

Figure 1 is a block diagram of a system for performing the invention;

Figure 2 is a flow diagram illustrating the operation of the system of Figure 1;

Figure 3 is a schematic perspective view of a portion of the control arrangement comprising the system of Figure 1;

Figure 4 is a schematic view of part of the system of Figures 1 to 3;

Figure 5 is a schematic representation of a first grid or array arrangement for determining the sequencing of irradiation of predetermined location on the body;

Figure 6 is a schematic representation similar to the representation of Figure 5, showing a further refined grid or array arrangement;

Figure 7 is schematic representation of a mask embodying the primary zone of the invention superimposed on a grid such as that showing Figures 5 and 6;

Figure 8 is a view similar to the view of Figure 4 for an alternative system utilising two separate irradiation beams;

Figure 9 is a schematic representation of the sequential irradiation achievable using an arrangement including three "working" lasers.

Referring to the drawings, and initially to Figures 1 to 7, there is shown a system for directing a beam of laser

radiation from an optical source 1 via an optical delivery arrangement 2 to irradiate the surface of a body 3 in a predetermined and controlled manner.

The laser parameters for the system are selected dependent upon the particular use for which the system is to be put. Parameters for several cosmetic uses are referred to above, in addition the laser parameters can be selected to perform a number of industrial tasks such as surface treatment or marking, for which lasers having parameters conventionally employed for these purposes may be used. Optical delivery arrangement 2 comprises a fibre optic cable which directs a beam of laser radiation toward combining optics 4 which includes optical focusing element 5 and a pair of galvanometric scanners 6, 7 each arranged to scan the directed laser beam in mutally perpendicular (XY) directions. The galvanometric scanners 6,7 include rotatable mirrors 8,9.

A control system 10 includes software embodied in a chip of a microcontroller 11 which controls the operation of the galvanometric scanners 6,7 to direct the beam to the appropriate location for impingement with the body 3 as will be described in further detail below. The hardware control also includes a digital/analog converter arrangement arranged to convert the digital signal output from the microcontroller 11 to the required analog signal to drive the rotation of mirrors 9,8. This enables galvanometric scanners 7,6 to assume the required rotational orientation to direct the beam to impinge with body 3 at the X, Y co-ordinates, dependant on the digital value generated by the microcontroller 11. A feedback comparator 29 is used to compare return voltages which are sent from the galvanometer electronics to confirm that the required rotation movement has occurred within the respective scanner 6,7.

The chip included in microcontroller 11 includes data which may be represented in the form of the grid arrays shown in Figures 5 and 6. The data stored is sequence data representing

the locations to which the radiation beam should be directed by the control arrangement 12 and the sequence in which the beam is to be directed to each location. For example, for the grid shown in Figure 5, the beam would first be directed to impinge with the square numbered 1, and then be directed to impinge in sequence with the numbered squares 2 to 16 in numerical order. The grid shown in Figure 5 is limited to sixteen laser pulses; the grid shown in Figure 6 is more detailed and embodies a further level of sequence data stored by the chip in microcontroller 11. In Figure 6, each of the numbered grid squares in Figure 5 is further sub-divided into sixteen sub zones, each sub zone representing a location of irradiation by the directed laser beam. Each sub zone is numbered 1 to 16 representing the order in which sub zones are to be irradiated.

A preferred form of laser direction sequenced by microcontroller 11 would be, for example, as follows:

First sub zone irradiated = sub zone 1 (Figure 6) in grid square 1 (Figure 5).

Second sub zone irradiated = sub zone 1 (Figure 6) in grid square 2 (Figure 5).

Third sub zone irradiated = sub zone 1 (Figure 6) in grid square 3 (Figure 5).

The sequence is continued until all sub zones 1 to 16 (Figure 6) for all grid squares 1 to 16 (Figure 5) have been irradiated. This system ensures that, for the particular use for which the system is employed (for example, depilation or skin resurfacing) adjacent surface locations are not irradiated consecutively. For alternative applications such as industrial surface treatment or surface marking, alternative sequence data may be stored which may, for example, direct adjacent surface locations to be irradiated (depending upon specific application requirements).

The data store also stores data relating to a mask overlay 20 (see Figure 7) which may be any geometric shape capable of tesselation but is preferably substantially hexagonal.

The mask overlay data is used in combination with data relating to the sequencing data embodied by the grid/arrays 5,6 to ensure that only sequence locations derived from the data grid arrays (Figures 5 and 6) is used which falls within the boundary of the geometric shape mask overlay 20.

In use, a mask 20 is selected which tesselates in the required manner to ensure that the surface of the body 3 to be irradiated can be covered in the most appropriate manner. Data relating to various shape geometries/sizes may be stored and selected.

A helium/neon laser beam is then directed from the optical source 1 via the fibre optic delivery system 2 to trace the outline of the mask overlay shape onto the surface of the body 3 to be irradiated. The helium/neon laser trace is scanned rapidly by galvanometric scanners 6,2 under the direction of the hardware control system 10,11 and does not physically mark the surface of body 3 but simply provides a projected image guide to the user to see where the primary zone will be irradiated when the "working" laser beam is directed to impinge in the selected sequence within the delimited primary zone. The system therefore comprises a first "delimiting" laser beam arranged to delimit the primary zone of the surface of the body to be irradiated, and second, "working" radiation beam to effect the surface treatment of the body 3. The system is therefore preferably operable in at least two distinct modes, the first being an outline delimiting mode permitting the operator to see the area to be irradiated; the second mode being a "treatment/working" mode (typically operated by means of a foot activated switch) sending a "working" laser pulse train to impinge with the pre-selected locations within the primary zone in the required sequence and for the required exposure time (as dictated by the controlling software and hardware). The system is provided with a feedback system to ensure that when a laser pulse train is correctly delivered to the required location (sub zones 1 to 16, shown in

Figure 6) flags are switched to record the successful firing of the beam. Switching of the flags ensures that no location (sub zones in Figure 6) are irradiated twice, and also that when misfires occur, a second attempt to irradiate the sequenced location is made.

For certain applications, for example for skin resurfacing, successive treatment with different "working" laser radiation beams is required. The scanner arrangement 12 may be arranged to receive incoming laser radiation beams from separate sources of "working" laser beams the axes of which are angularly spaced (see Figure 8). In this embodiment the sequence and timing data stored in chip of microcontroller 11 stores data for controlling the respective locations to which each laser is to be directed and also the order in which each "working" beam laser is to be fired. Galvanometer scanners 6,7 then rotate appropriately to ensure that the beams from the respective "working" laser radiation sources are directed to the appropriate location for impingement with the surface of body 3 in the primary zone. Figure 9 shows how the arrangement of Figure 8 may be used to sequence laser pulses of three separate "working" laser beams.

CLAIMS:

1. A method of irradiating a body, which method comprises;
   i) delimiting a primary zone on the surface of the body to be irradiated;
   ii) directing radiation to irradiate the body at a plurality of predetermined locations within the primary zone in a predetermined sequence.

2. A method according to claim 1, wherein the primary zone delimited is of predetermined configuration.

3. A method according to claim 1 or claim 2, wherein the primary zone delimited is of a predetermined space filling shape, which shape is configured to tesselate.

4. A method according to any preceding claim, wherein the predetermined sequence of irradiating the predetermined locations within the primary zone results in irradiation over substantially the entire primary zone.

5. A method according to any preceding claim, wherein the sequence of irradiating the predetermined locations within the primary zone is such that spatially adjacent locations do not correspond to sequentially adjacent locations.

6. A method according to any of claims 1 to 4, wherein the sequence of irradiating the predetermined locations within the primary zone is such that spatially adjacent locations correspond to sequentially adjacent locations.

7. A method according to any preceding claim, wherein the predetermined locations are assigned corresponding respective flags the status of the flags being switched upon irradiation of the respective predetermined location.

8. A method according to any preceding claim, wherein the predetermined locations are assigned to respective elements in a grid or array, each grid or array element being alloted a predetermined respective position in the heirarchy of the predetermined sequence of irradiation.

9. A method according to claim 8, wherein the grid or array comprises a plurality of sub-zones, respective sub-zones comprising a grouping of respective grid elements or array elements and being assigned a respective heirarchical position in the predetermined sequence of irradiation, and wherein irradiation of a location assigned to a respective grid or array element in a first sub-zone is followed by irradiation of a location assigned to a respective grid or array element in a second sub-zone prior to irradiation of a further location assigned to a respective grid or array element in the first sub-zone.

10. A method according to any preceding claim, further comprising:
 iii) delimiting a further primary zone on the surface of the body to be irradiated;
 iv) directing radiation to irradiate the body at a plurality of predetermined locations within the further primary zone in a predetermined sequence.

11. A method according to claim 10, wherein the further primary zone lies adjacent the first irradiated primary zone.

12. A method according to any preceding claim, wherein the radiation directed comprises a beam of radiation.

13. A method according to claim 12, wherein the radiation directed comprises a beam of laser radiation.

14. A method according to claim 12 or claim 13, wherein the radiation beam comprises a pulsed beam.

15. A method according to any of claims 12 to 14, wherein a plurality of radiation beams are provided, each directed to irradiate the body at a plurality of predetermined locations within the primary zone in a respective predetermined sequence.

16. A method according to claim 15, wherein the plurality of radiation beams are sequenced to be directed at spaced temporal intervals to the same predetermined locations within the primary zone in a respective predetermined sequence.

17. A method according to any preceding claim, wherein the primary zone is delimited on the surface of the body by imaging the shape of the primary zone.

18. A method according to claim 17, wherein the primary zone is delimited on the surface of the body by imaging the boundary of the primary zone.

19. A method according to any preceding claim, wherein the primary zone is delimited on a superficial area of mammalian skin.

20. Apparatus for irradiating a body, the apparatus comprising:
   i) delimitation means for delimiting a primary zone on the surface of the body toward which radiation is to be directed; and,
   ii) control means for controlling delivery of radiation toward the primary zone, the control means directing radiation to irradiate the body at a plurality of predetermined locations within the primary zone in a predetermined sequence.

21. Apparatus according to claim 20, wherein the delimitation means delimits the primary zone as a zone of predetermined configuration.

22. Apparatus according to claim 20 or claim 21, wherein the delimitation means delimits the primary zone as a zone of predetermined space filling shape, which shape is arranged to tesselate.

23. Apparatus according to any of claims 20 to 22, wherein the delimitation means delimits the primary zone as an hexagonal zone.

24. Apparatus according to any of claims 20 to 23, wherein the delimitation means comprises means for non-physically marking the surface of the body.

25. Apparatus according to any of claims 20 to 24, wherein the delimitation means comprises imaging means for imaging the shape of the primary zone on the surface of the body.

26. Apparatus according to claim 25, wherein the delimitation means comprises means for projecting a beam of radiation to image the shape of the primary zone on the surface of the body.

27. Apparatus according to any of claims 20 to 26, wherein the control means comprises data store means including stored data relating to the predetermined locations to be irradiated in the primary zone.

28. Apparatus according to claim 27, wherein the data store means includes sequence data dictating the predetermined sequence for irradiation of the predetermined locations within the primary zone.

29. Apparatus according to claim 27 or claim 28, wherein the data storage means includes a flag arrangement, wherein respective flags are set from a first condition to a second condition in order to confirm that a respective location of the primary zone has been irradiated.

30. Apparatus according to any of claims 27 to 28, wherein the data storage means comprises a microcontroller arrangement.

31. Apparatus according to any of claims 20 to 30, wherein the control means includes a radiation director arrangement, the radiation director arrangement being reorientatable to direct the radiation in sequence to the plurality of locations within the primary zone.

32. Apparatus according to claim 31, wherein the radiation director arrangement comprises a pivotable deflector or reflector arrangement.

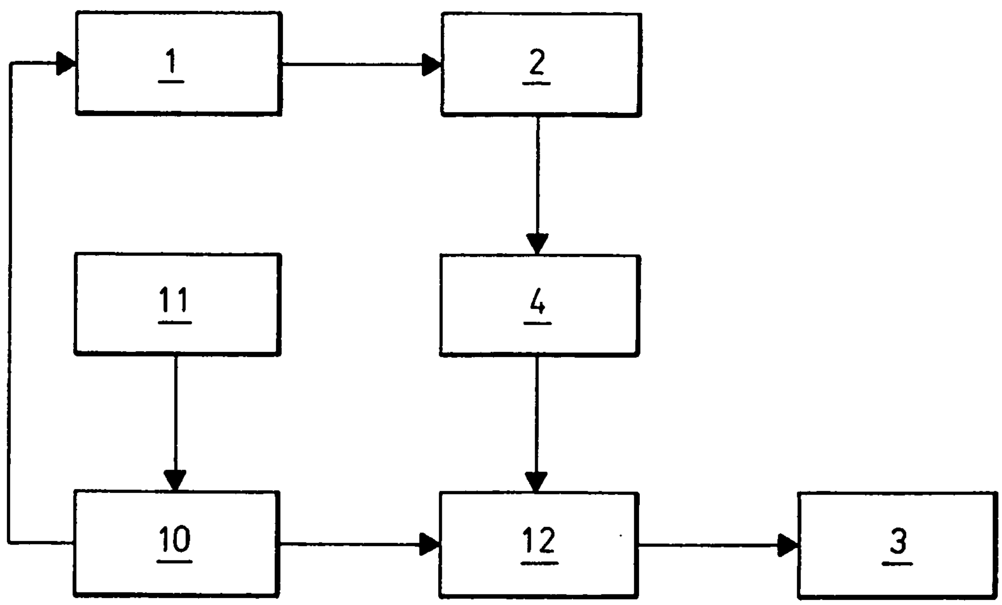
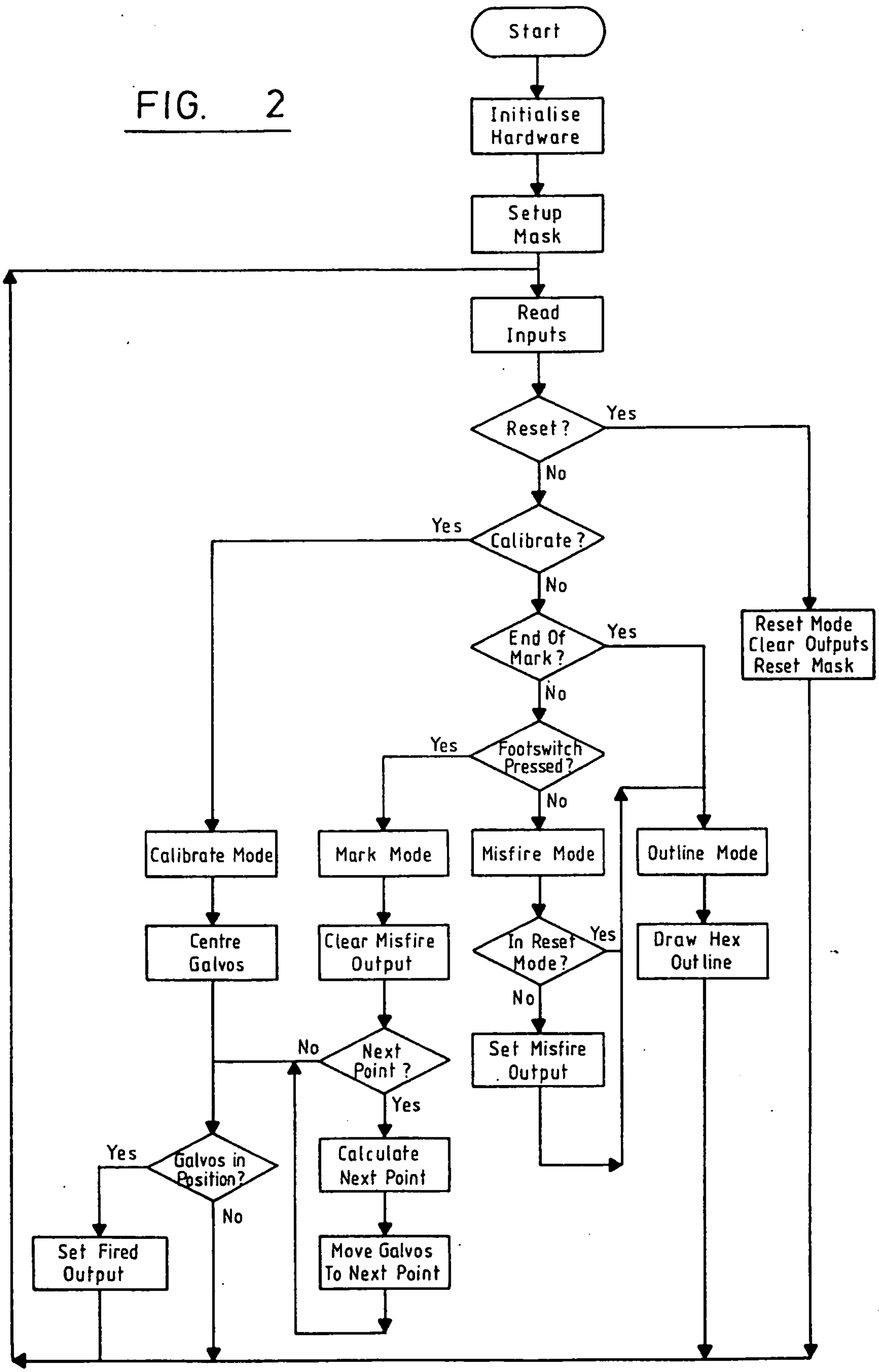


FIG. 1

FIG. 2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Read Inputs
Reset ?
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No
Calibrate ?
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No
End Of Mark ?
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Footswitch Pressed ?
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Reset Mode Clear Outputs Reset Mask
Calibrate Mode
Mark Mode
Misfire Mode
Outline Mode
Centre Galvos
Clear Misfire Output
In Reset Mode ?
Yes
No
Draw Hex Outline
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No
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Set Fired Output
Move Galvos To Next Point

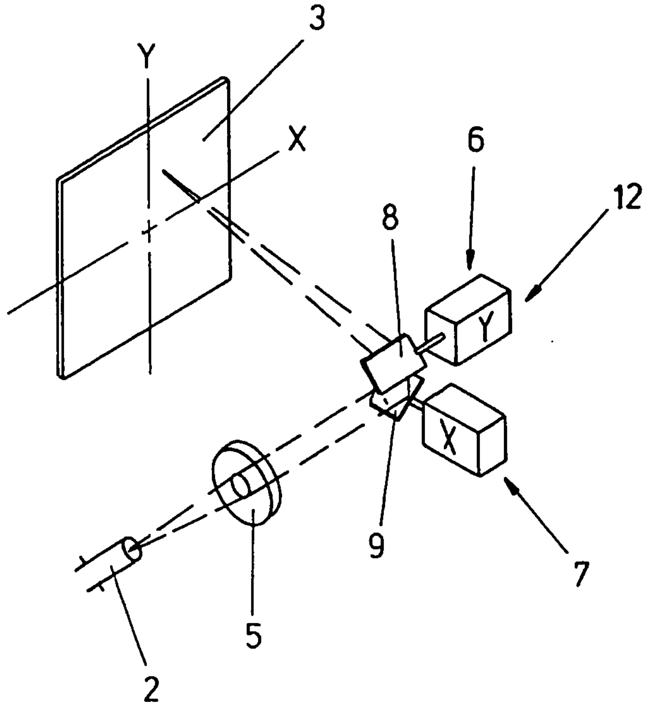


FIG. 3

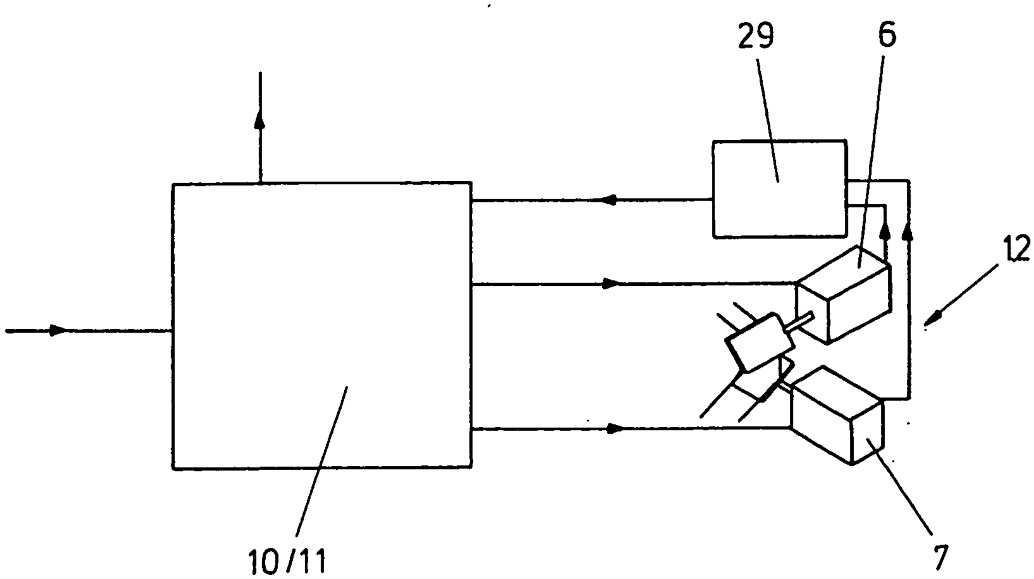
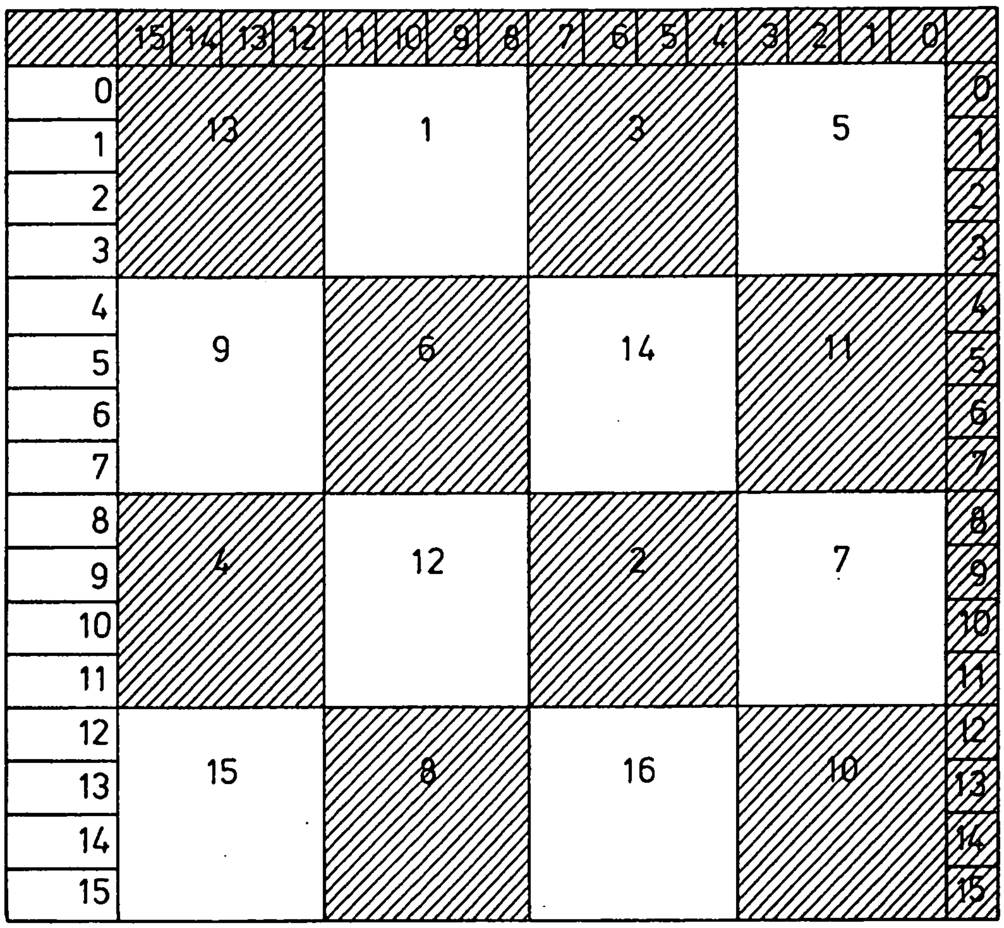


FIG. 4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0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15
13 1 3 5
9 6 14 11
4 12 2 7
15 8 16 10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

FIG. 5

	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
0	13	1	3	5	13	1	3	5	13	1	3	5	13	1	3	5	0
1	9	6	14	11	9	6	14	11	9	6	14	11	9	6	14	11	1
2	4	12	2	7	4	12	2	7	4	12	2	7	4	12	2	7	2
3	15	8	16	10	15	8	16	10	15	8	16	10	15	8	16	10	3
4	13	1	3	5	13	1	3	5	13	1	3	5	13	1	3	5	4
5	9	6	14	11	9	6	14	11	9	6	14	11	9	6	14	11	5
6	4	12	2	7	4	12	2	7	4	12	2	7	4	12	2	7	6
7	15	8	16	10	15	8	16	10	15	8	16	10	15	8	16	10	7
8	13	1	3	5	13	1	3	5	13	1	3	5	13	1	3	5	8
9	9	6	14	11	9	6	14	11	9	6	14	11	9	6	14	11	9
10	4	12	2	7	4	12	2	7	4	12	2	7	4	12	2	7	10
11	15	8	16	10	15	8	16	10	15	8	16	10	15	8	16	10	11
12	13	1	3	5	13	1	3	5	13	1	3	5	13	1	3	5	12
13	9	6	14	11	9	6	14	11	9	6	14	11	9	6	14	11	13
14	4	12	2	7	4	12	2	7	4	12	2	7	4	12	2	7	14
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FIG. 6

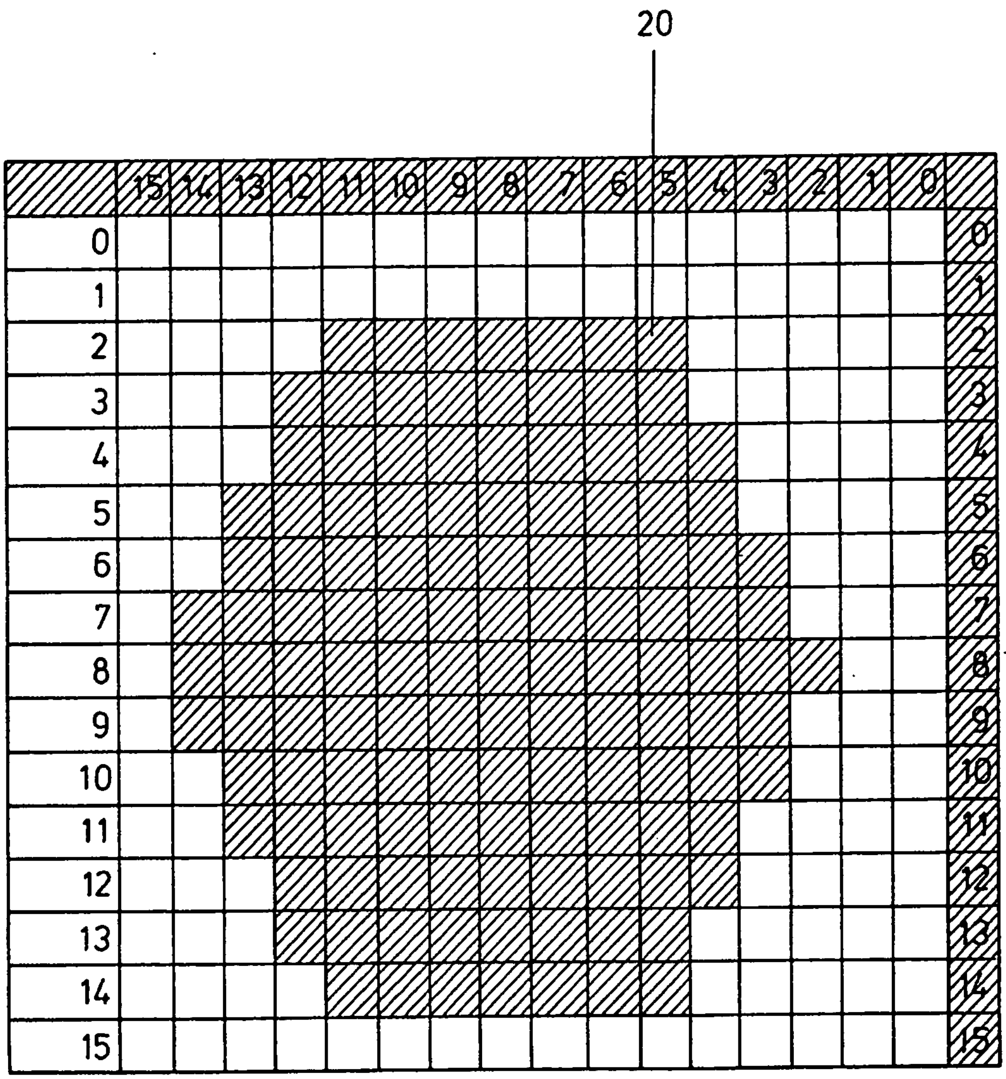

FIG. 7

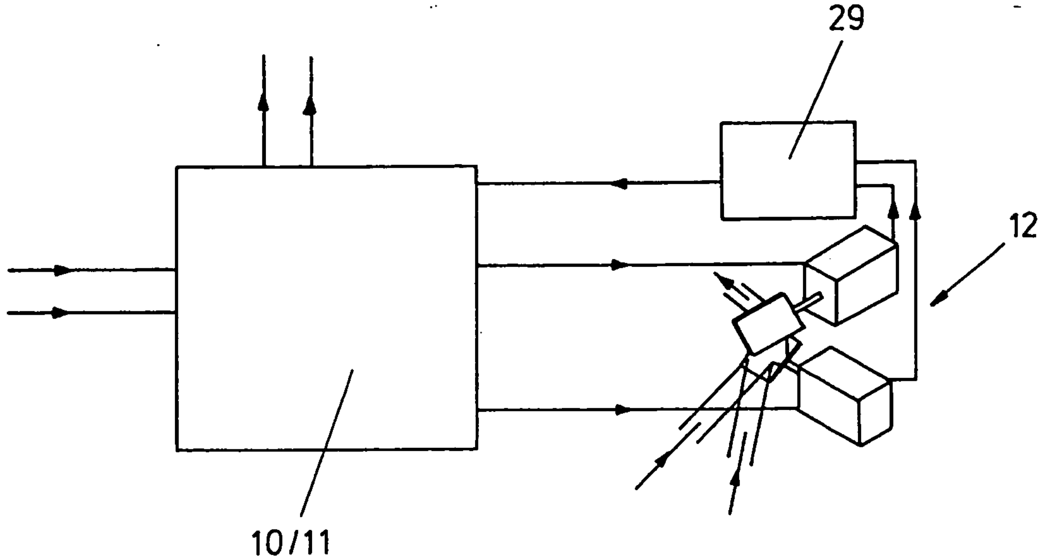
29
12
10/11

FIG. 8

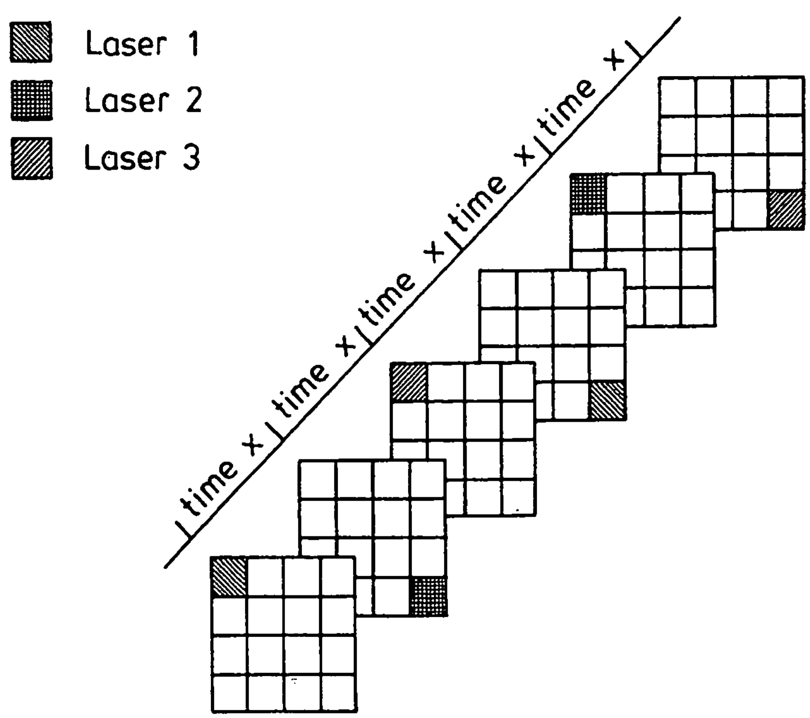
Laser 1
Laser 2
Laser 3
| time x | time x | time x | time x | time x | time x |

FIG. 9

INTERNATIONAL SEARCH REPORT

Internat'l Application No
PCT/GB 97/03358

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 A61N5/06

According to International Patent Classification(IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 A61N

Documentation searched other than minimumdocumentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 95 27535 A (KLOPOTEK) 19 October 1995 see abstract; claim 1	1-32
X	EP 0 473 861 A (MORETTI) 11 March 1992 see abstract; claims 1,2; figure 1	1-32

☐ Further documents are listed in the continuation of box C.

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/GB 97/03358

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9527535 A	19-10-1995	AU 2205395 A	30-10-1995
EP 0473861 A	11-03-1992	NONE	